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The Commonwealth of Massachusetts

Department of Labor and Industries

DIVISION OF OCCUPATIONAL HYGIENE

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

I. LEAD STORAGE BATTERY MANUFACTURE

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FOREWORD

The survey described in the following report is one of a series of industrial health studies conducted by the Division of Occupational Hygiene of the Massachusetts Department of Labor and Industries, in co-operation with the Works Progress Administration, as part of the Industrial Chemical Survey Project, W. P. A. No. 65-14-6060. This survey was supervised by Hervey B. Elkins, chemist, and W. C. L. Hemeon, engineer of the division. The purpose of this work is to secure, as a basis for constructive preventive effort, knowledge of the extent and manner of use of the more important potentially hazardous chemicals in the industries of the Commonwealth. The wholehearted assistance of the establishments visited is gratefully acknowledged.

THE SERVICES OF THE DIVISION OF OCCUPATIONAL HYGIENE ARE AVAILABLE ON REQUEST IN CONNECTION WITH MATTERS PERTAINING TO THE HEALTH OF INDUSTRIAL AND MERCANTILE WORKERS.

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

I. LEAD STORAGE BATTERY MANUFACTURE

The manufacture of lead storage batteries has, for years, been recognized as an industry involving a lead poisoning hazard to an extreme degree. Alice Hamilton (American Federationist, July, 1936) says "The industry which, in my opinion, is responsible for the greatest number of cases of lead poisoning is storage battery manufacture. Although we have insufficient statistics to prove it, that is the case in England where they do have complete statistics and in Germany, . . ."

In recent years deaths from lead poisoning have been rare. In the entire country for the years 1925-1927, there were five deaths (Bulletin 488, U. S. Bureau of Labor Statistics) from lead poisoning contracted in storage battery plants. Such statistical data, however, do not have the importance that might at first glance be attached to it, for, as stated by Hoffman, (Safety Engineering, June, 1928, "The Lead Poisoning Hazard") "Deaths from lead poisoning cannot reveal the true extent of the evil of lead absorption. The latter for practical purposes is much more important than the former in that in certain industries lead absorption is exceedingly common though rarely terminating in fatal form. In no industry is this perhaps more true than in the manufacture of electric storage batteries which, however, during recent years has made extraordinary progress in bringing the matter under control."

The most recent statistical data for Massachusetts is indicated in Table I.

Table I

Number storage battery plants in Massachusetts. (1934)	3
Number wage earners in Massachusetts storage battery plants. (1934)	48
Annual average of lead poisoning cases in storage battery plants investigated by the Department of Labor and Industries. (1929-34)	7
Fatal cases	None

This survey was conducted during the winter and spring of 1936. Four plants were visited and studies of lead exposure were made in three which involved making twenty-six determinations of the lead concentration in as many working atmospheres. The lead content of the air was determined by collection of solid material from the atmosphere with the Greenburg-Smith impinger apparatus, followed by chemical analysis of the resulting sample.

General Precautions

The extent to which various general preventive measures were found to be employed in this industry is set forth in Table II.

Table II

Safety engineer	0	Shower baths	2
Plant physician (part time)	1	Respirators provided	3
Physical examination on employment	1	Compensation insurance carried	0
Periodic examination	1	Mechanical ventilation	3

Process of Manufacture

The process of storage battery manufacture will be only briefly described in order to make clear the significance of the results of atmospheric analyses herewith reported.

Batteries made in Massachusetts factories today are of the Faure type. The factories making them are small, the largest employing about 20 workers, and the smallest, 2 to 3 workers. In the largest plant as many as 75 workers have been engaged when business conditions warranted.

In the plate casting department, grids or battery plates are cast of lead. (This metal contains some antimony.) This is a hand operation, although a rapid one; a workman frequently averages about 250 plates per hour. The casters stand around a large heated crucible, in which the melted lead is maintained at a temperature of about 1200° F. These pots usually have a hood over them which may, or may not, be equipped with an exhaust fan. There is infrequent occasion for the workmen to walk away from their workplace.

The next principal operation is the mixing of the paste. Red lead and litharge are weighed into mixing tubs from barrels, the tub being part of the ordinary pony mixer. Water and sulphuric acid are added to the powdered oxides which are thus reduced to a paste form.

The resulting paste is transported to the pasting department where the interstices of the grids are filled with the paste, either with a trowel by hand, or by means of a pasting machine. The latter contrivance requires the services of 1 to 3 men, depending on the type of machine and does little to make the operation less messy than the hand operation.

The wet plates are then transferred to racks for drying. In some cases this is done in hot air chambers, but more frequently in the smaller plants, by air drying. The dried plates, hitherto attached together in pairs, are separated and brushed mechanically to smooth broken corners and remove dust.

In the assembly department the various parts are brought together and assembled, the principal operation being group burning. This consists in placing the positive and negative plates filled with dried paste in racks and attaching lead connectors by means of a gas-oxygen torch.

Subsquent operations involve charging the plates electrically, placing these units in the casing, and attaching covers.

FORMS OF LEAD

As will be noted from the preceding discussion the lead used in storage battery manufacture is in three forms: litharge—PbO; red lead—Pb_3O_4; and metallic lead. The latter is doubtless oxidized on vaporization at the high temperatures at which this takes place. These forms of lead are all quite readily soluble in blood serum when present in a finely divided state, as in a dust or fume. They will therefore be absorbed into the blood stream without delay when inhaled, and symptoms of lead poisoning may rapidly develop if there has been a heavy exposure. In the typical cases, however, no symptoms develop until after months or years of exposure to relatively low concentrations of dust or fume.

LEAD EXPOSURES IN VARIOUS WORKING AREAS

Table III summarizes our findings as to amounts of lead found in the atmosphere at various stages in the manufacturing operations. For purposes of comparison some values reported in the extensive investigation of the U. S. Public Health Service in a large battery plant have been included. It was established by that investigation that the maximum permissible concentration for continued exposure day in and day out is 1.5 milligrams per 10 cubic meters. That is, lead absorption resulting eventually in lead poisoning to the average worker will occur if he is consistently exposed to higher concentrations and if the concentration be appreciably less than that value the chances of his contracting lead poisoning are very small.

The results, it will be noted, have been grouped according to the general nature of the operations involved. Because of the small scale on which the plants operate it was not practical to segregate operations to any great extent. This is partly because a single workman frequently does several operations and partly because air samples taken near a given operation did not reflect the nature of that operation but rather the general air of the workroom.

PLATE CASTING, ETC.

The general air in the vicinity of plate casting operations, drying rooms, etc., was found to have a lower lead content than that of any other part of the process. The reason for this is to be found in the fact that there are no inherently dusty operations in the immediate vicinity. The floors are not clean, but there is little walking about by workmen.

TABLE III

General Air in Characteristic Working Areas	Milligrams lead per 10 cu. meters air		
	Range of Concentrations	Average Concentration	Results Found in a Study by U. S. P. H. S.
Plate casting, small parts casting, drying room, repairing. (*Very little walking about, or no active source of lead dust.*)	1.0 - 3.9	2.6	1.3*
Mixing Room. (*Handling of raw oxide powder. Large exhaust fans drawing on air from pasting room.*)	4.5 - 8.8	6.6	164
Pasting Room. (*Dried paste on equipment, workers' clothes, and floor.*)	11 - 21	16	16
Assembly Room. Plate breaking, grouping and group-burning. (*Handling of dry plates.*)	9.4 - 18	13	5.7
Air at Breathing Zone in Specific Occupation			
Group Burners. (*Fumes from fusing lead and dust from dried plates.*)	9 - 61	31	4.0
Plate Casters. (*Fumes from molten lead.*)	2.5 - 11	6.5	1.9

* Applies only to Plate Casting.

PASTING

In the vicinity of the pasting operations it will be noted that the lead content of the air is high. As is noted in Table III, all this dust is from dried paste on the pasting machine, on the pasting bench, on the workmen's clothes, and on the floor. There is considerable activity in this area. The result is that this dried paste is brushed against, walked on, and disseminated into the air.

One sample of air taken near the chin of an operator on a pasting machine showed twice the concentration of lead found three or four feet away, indicating that he himself is an important source of dust. The U. S. Public Health Service figure is also of the general air but similar samples taken close to the operator's breathing zone showed 3 to 7 times as high a concentration which tends to confirm this conclusion.

MIXING

In all cases where samples were obtained of the air around the mixing tubs, powerful exhaust fans were operating, and the net result was an air movement from the pasting room or pasting area into the mixing room. It will be noted that the lead content of the air in the mixing rooms is quite a bit lower than in the pasting room. This is a reflection of the care that has been taken to reduce the exposure in what formerly was one of the most hazardous occupations in storage battery plants. An example of such a condition can be seen in the U. S. Public Health Service study in which lead concentrations in the mixing room were 25 times the average found in Massachusetts plants.

The latter concentration is still, however, three to six times the concentration considered safe. Moreover, in none of these plants do any workmen spend a major proportion of their time in the mixing room, particularly with business activity at its present level.

ASSEMBLY ROOM

The general air of the assembly room shows a lead content not substantially different from that in the vicinity of the pasting operations. In this room the principal activities involve the handling of dry plates. The paste although dry, is friable and some of it dusts off whenever jarred even slightly. Again, as in the pasting section, there is considerable dust on the floor which is walked upon and disseminated into the air.

GROUP BURNING

In group burning the air, in all cases, was sampled close to the operator's chin. As will be noted, the range of concentrations of lead found was greater here than in any other section. The torch used to weld the lead for the purpose of joining the various plates together results in a localized high temperature which causes considerable volatilization and oxidation of the metallic lead. This condition also results in a strong upward current of air and lead fumes toward the face of the operator. The lead fumes breathed by the group burner are in two forms: one, this very finely divided, oxidized lead from the metal; the other, somewhat coarser dust from the rubbing together of the dry paste in the plates.

In one case where downward draft was provided in the work bench, the dust from the plates was more or less effectively removed and the concentration of lead in the air breathed by the burner was around 23 mg. per 10 cubic meters. In the case of the highest concentration found in this operation, no means at all had been provided for the removal of either source of lead. In the case of the lowest lead concentration found, it is believed that the figure is not representative of average practice since no ventilation of any kind was provided here.

The very low figure reported in the U. S. Public Health Service work is probably to be accounted for partly by improved exhaust and partly by the fact that at this stage in the operations the work in this factory travels on a conveyor system obviating the necessity for excessive handling of the plates.

In the opinion of those connected with this industry in Massachusetts, group burning is the most hazardous occupation in the plant. Our observations, as can be seen in Table III, are consistent with this point of view. Although in some cases the concentration at the group burner was not much higher than that around some pasting operations, the character of this lead is obviously different inasmuch as the fumes formed from the volatilization of lead are in extremely finely divided condition. It is reasonable to believe that this might markedly increase the rate of onset of lead poisoning and thereby account for the poor opinion in which this occupation is regarded.

FLOOR CLEANING

It was shown during the course of this investigation that the atmosphere of such a workroom could become markedly more hazardous right after washing with water due to the broom-like action of the stream of water. One mixing room, on the floor of which lead dust lay, had in its normal atmosphere 8.8 mg. of lead per 10 cubic meters; the same atmosphere one hour after a vigorous hosing contained 24 mg.

SUMMARY AND CONCLUSIONS

There is a very great lead hazard in storage battery plants in Massachusetts which is only in part mitigated by part time employment of workers, a result of the present depressed state of this industry.

Pasting and assembling operations are the most hazardous occupations in these plants although the factories in general are so small that workers seldom are kept at a single occupation and hence there can be little practical difference in occupational exposures. A possible exception to this is in plate casting which is in some cases a specialized occupation.

The areas in which mixing is done are more free of lead dust than has been true in plants of this type in the past, as indicated in reports of other studies.

Local exhaust ventilation facilities for removing lead dust and fumes at their sources varied quite widely between the different plants. It can be said, in general, that the greatest need in these plants is not increased exhaust ventilation but rather various improvements toward increased general cleanliness and good housekeeping as, even in the best equipped plants (from the standpoint of local exhaust systems), the hazard is still considerable.

WHAT CAN BE ACCOMPLISHED

The investigation of the Department of Labor and Industries of Pennsylvania may be cited as an example of what can be done in the control of lead dust in storage battery manufacture. This investigation by Dr. Elizabeth Bricker involved the physical examination of 37 workers in a certain battery plant and 27 atmospheric analyses in various parts of the factory for lead content. The physical examinations uncovered no cases of marked lead poisoning. Of the 27 samples of air taken in this plant only 4 contained more than 3.0 milligrams of lead per 10 cubic meters. Of 7 samples taken in the pasting room 2 showed no lead present, and the greatest amount found at any one point was 2.2 milligrams per 10 cubic meters.

RECOMMENDATIONS

An accumulation of dust on floors, sills, and other places of lodgement is apparent at all such plants. Two methods of correcting this situation are available. One is the use of industrial vacuum cleaners which is by far the more satisfactory, and the other is the frequent washing of the floors in such a way as to float the dust from the floor surfaces rather than to wet it and then permit it to dry, still on the floor.

Such a hosing should be done at the close of the workday and the workmen doing this should wear a lead dust respirator. General ventilation should be provided for in order to clear the air of the room from the fine invisible dust generated, since the particle size of the dust is much too small to settle out overnight. These remarks apply as well to vacuum cleaning when the cleaner is a portable device since the bag filter is in the room and is not capable of removing all dust particles from the air passing through it.

The pasting operations share first place with assembling for the doubtful honor of being the most hazardous operation in these battery plants. The reason for the excessive dust from this operation is the lack of cleanliness of the equipment and of the clothes of the workmen, as well as of the floors around this process. This situation could be remedied by the provision of working uniforms for the men which should be washed free of dried lead paste and dust at least every two days. Secondly, all pasting equipment should be thoroughly washed daily, and partially two or three times a day around the most active parts, wherever drying of the paste can take place and be brushed against or otherwise disturbed.

The problem of controlling the lead fumes from group burning is one of local exhaust of a dual nature, namely, one which would withdraw the heavy dust through gratings in the work bench and an overhead hood which would prevent breathing of the fumes which rise from the burning. Such a hood should be of such construction and so operated as to deflect the column of rapidly rising air and lead fumes before it reaches the face of the burner.